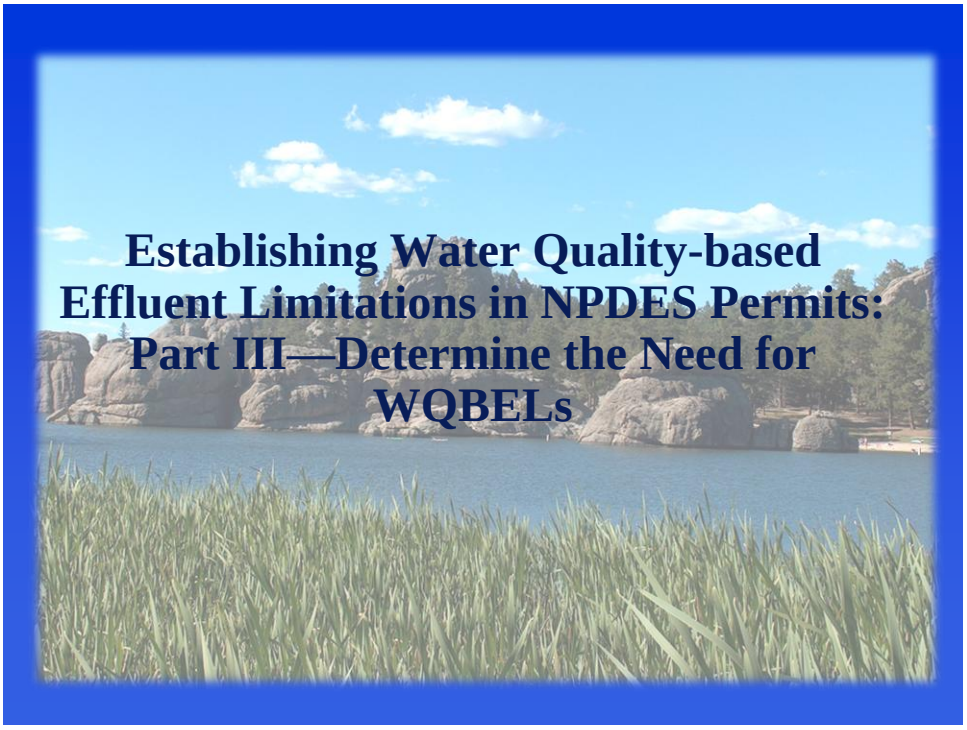


Today's Speakers

- ***David Hair***
  Environmental Engineer
  US Environmental Protection Agency
  Washington, DC

- ***Greg Currey***
  Environmental Engineer
  Tetra Tech, Incorporated
  Fairfax, Virginia

WQBELs Part III-2

Establishing WQBELs in NPDES Permits

Part I: Identify Applicable Water Quality Standards

↓

Part II: Characterize the Effluent and Receiving Water

↓

Part III: Determine the Need for WQBELs

↓

Part IV: Calculate Chemical-specific WQBELs and Determine Final Limitations

WQBELs Part III-3

Part I Review: Relationship Between WQS and Effluent Limitations

- **Recall from Part I (Identify Applicable WQS):**
  - Water quality ***standards*** apply throughout the waterbody (or segment of a waterbody) as defined by the state, territory, or tribe
  - ***Effluent limitations*** apply at the compliance point established in the permit (generally "end of pipe")

WQBELs Part III-4

Part I Review: Relationship Between WQS and Effluent Limitations

Water Quality Criteria
- Magnitude
- Duration
- Frequency

→

Effluent Limitations
- Magnitude
- Averaging Period

Permit writers calculate end-of-pipe water quality-based effluent limitations where necessary to ensure that water quality standards are attained in the receiving water.

Part I Review: WQS Implementation Procedures

- **Water quality standards and their implementing procedures (including NPDES requirements) specify methods for determining the need for WQBELs and for calculating WQBELs that ensure that standards are attained.**
- **Where can these methods be found?**
  - **EPA's *Technical Support Document***
  - **State regulations**
  - **State water quality management plans**
  - **State guidance**
  - **past practices**
  - **We never thought about this before!**

Part II Review: Identify Pollutants of Concern

§ 433.14 Effluent limitations representing the degree of effluent reduction attainable by applying the best available technology economically achievable (BAT).

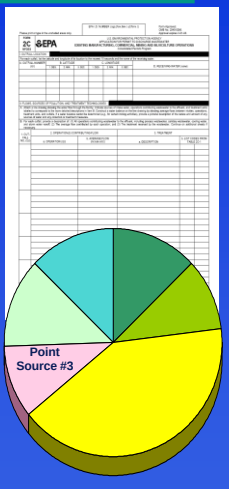
(a) Except as provided in 40 CFR 125.30 through 125.32, any existing point source subject to this subpart must achieve the following effluent limitations representing the degree of effluent reduction attainable by applying the best available technology economically achievable (BAT):

BAT Effluent Limitations

Pollutant or pollutant property	Maximum for any 1 day	Monthly average shall not exceed
	Milligrams per liter (mg/l)	
Cadmium (T)	0.69	0.26
Chromium (T)	2.77	1.71
Copper (T)	3.38	2.07
Lead (T)	0.69	0.43
Nickel (T)	3.98	2.38
Silver (T)	0.43	0.24
Zinc (T)	2.61	1.48
Cyanide (T)	1.20	0.65
TTO	2.13	

Recall from Part II (Characterize Effluent and Receiving Water) that pollutants of concern are pollutants:

- With an applicable technology-based effluent limitation (TBEL)
- With a wasteload allocation (WLA) from a total maximum daily load (TMDL)
- Identified as needing WQBELs or monitoring in the previous permit
- Identified as present in the effluent through monitoring
- Otherwise expected to be present in the discharge



WQBELs Part III-7

Part II Review: Determine the Allowable Dilution or Mixing Zone in the Receiving Water

Also recall from Part II (Characterize Effluent and Receiving Water) that we need to:

- Determine whether water quality standards permit dilution allowances or mixing zones
- Determine critical conditions (e.g., critical stream flow)
- Determine type of mixing under critical conditions
  - rapid and complete mixing
  - incomplete mixing
- Determine dilution allowance or regulatory mixing zone size for calculations

WQBELs Part III-8

Establishing WQBELs in NPDES Permits

Part I: Identify Applicable Water Quality Standards

↓

Part II: Characterize the Effluent and Receiving Water

↓

Part III: Determine the Need for WQBELs

↓

Part IV: Calculate Chemical-specific WQBELs and Determine Final Limitations

WQBELs Part III-9

Part III: Determining the Need for Chemical-specific WQBELs

When must a permit writer establish effluent limitations using water quality criteria?

Answer: Limitations must be established in permits to control all pollutants or pollutant parameters that are or may be discharged at a level that will ***cause***, have the ***reasonable potential to cause***, or ***contribute*** to an excursion above any state water quality standard [40 CFR 122.44(d)(1)(i)].

WQBELs Part III-10

Is There Reasonable Potential?

Limitations must be established in permits to control all pollutants or pollutant parameters that are or may be discharged at a level that will ***cause***, have the ***reasonable potential to cause***, or ***contribute*** to an excursion above any state water quality standard.

WQBELs Part III-11

Steady-State Modeling

- Predicts the impact of the effluent on the receiving water for a ***single set of conditions***
- Can be used in both ***rapid and complete mixing*** and ***incomplete mixing*** situations
- Generally assumes that the single set of conditions are the ***critical conditions*** for flow, pollutant concentrations, and environmental effects

WQBELs Part III-12

Dynamic Modeling

- Accounts for *variability* of model inputs
- Projects *probability distributions* rather than a single value based on critical conditions
- *Data intensive* and *complex*

WQBELs Part III-13

Is There Reasonable Potential?

For steady-state modeling under critical conditions:

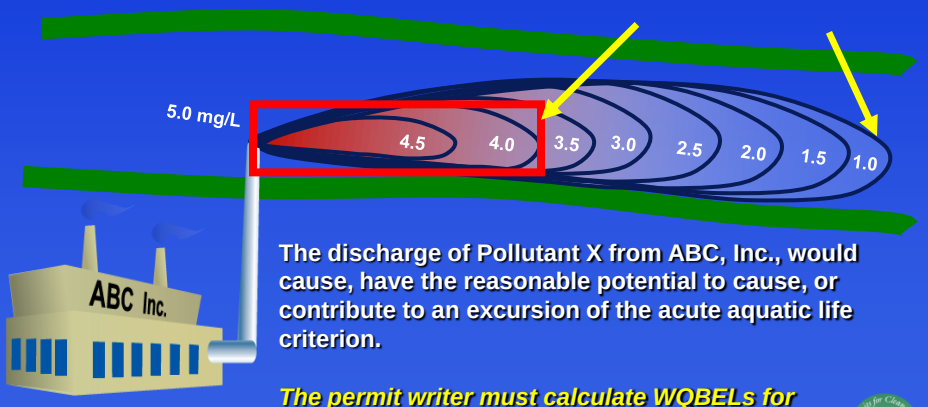
- If the receiving water concentration *exceeds* the applicable water quality criterion, then there is *reasonable potential* and the permit writer must establish WQBELs
- If the receiving water concentration is *equal to or less than* the applicable water quality criterion, then there is *no reasonable potential* and we have not demonstrated a need to establish WQBELs

WQBELs Part III-14

Expected Receiving Water Concentrations for Steady-State, Incomplete Mixing Under Critical Conditions

Steady-State, Incomplete Mix Assessment

Acute Aquatic Life Water Quality Criterion for Pollutant X = 1.0 mg/L

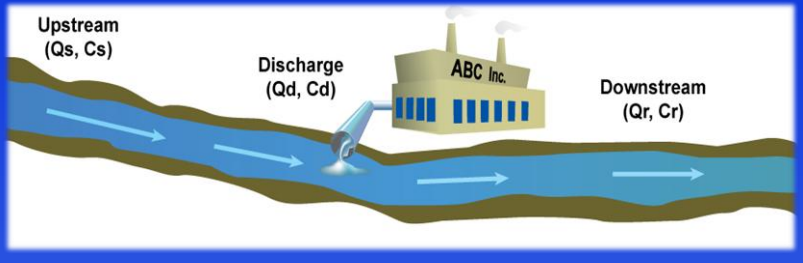


The discharge of Pollutant X from ABC, Inc., would cause, have the reasonable potential to cause, or contribute to an excursion of the acute aquatic life criterion.

The permit writer must calculate WQBELs for Pollutant X.

WQBELs Part III-15

Expected Receiving Water Concentration for Steady-State, Rapid and Complete Mixing Under Critical Conditions

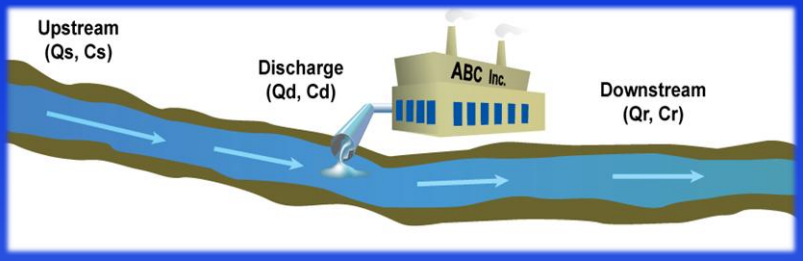


Mass-Balance Equation: QsCs + QdCd = QrCr

- **Q = Flow (mgd or cfs)**
- **C = Pollutant concentration (mg/l)**
- **Mass = [Concentration] [Flow]**

WQBELs Part III-16

Steady-State Complete Mix Assessment
QsCs + QdCd = QrCr

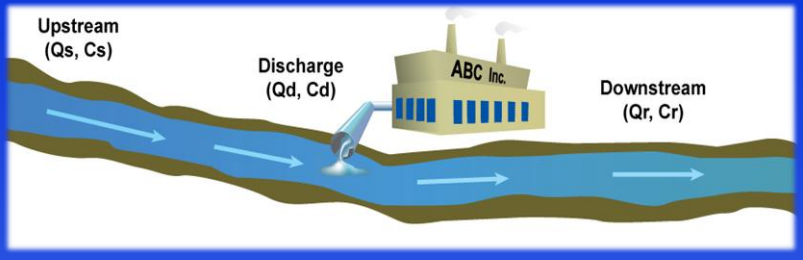


Determine the pollutant concentration of Pollutant X (the pollutant of concern) in the water body downstream of the discharge:

$$Cr = \frac{QsCs + QdCd}{Qr}$$

WQBELs Part III-17

Calculating Receiving Water Concentration Under Critical Conditions



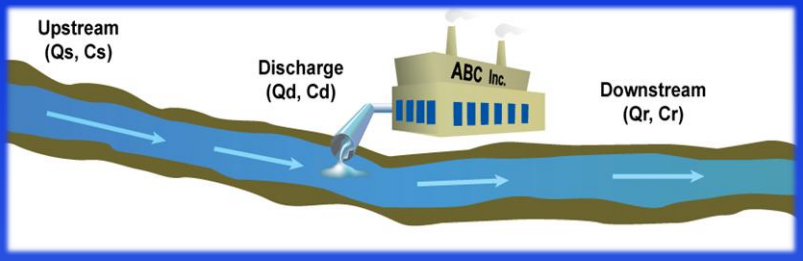
Criterion for protection of aquatic life from acute effects from Pollutant X = 1.0 mg/L

Qs	=	Critical stream flow (1Q10) for acute criterion	= ???????
Qd	=	Critical effluent flow from discharge flow data	= ???????
Qr	=	Sum of critical stream flow and critical effluent flow	= ???????
Cs	=	Critical upstream pollutant concentration	= ???????
Cd	=	Critical effluent pollutant concentration	= ???????

$$Cr = \frac{QsCs + QdCd}{Qr}$$

WQBELs Part III-18

Steady-State Complete Mix Assessment
QsCs + QdCd = QrCr

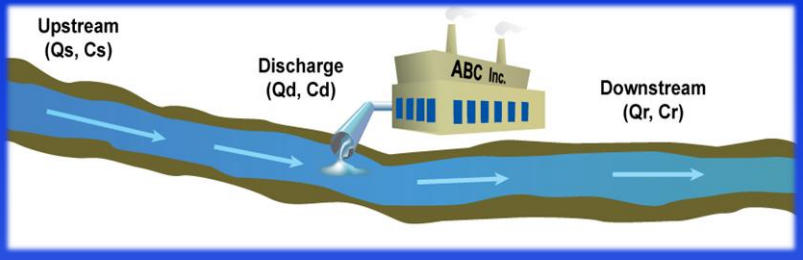


$$Cr = \frac{QsCs + QdCd}{Qr}$$

Qs = Critical *stream flow* from water quality standards

WQBELs Part III-19

Calculating Receiving Water Concentration Under Critical Conditions



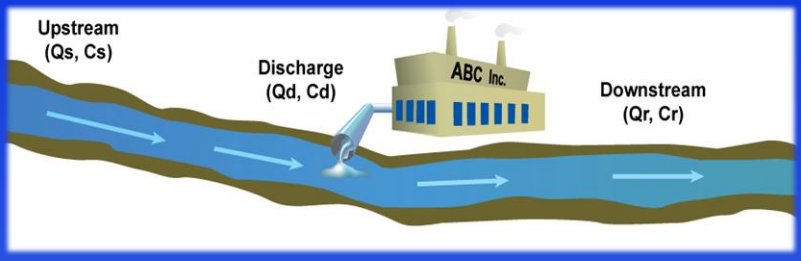
Criterion for protection of aquatic life from acute effects from Pollutant X: = 1.0 mg/L

Qs	=	Critical stream flow (1Q10) for acute criterion	= 1.2 cfs
Qd	=	Critical effluent flow from discharge flow data	= ???????
Qr	=	Sum of critical stream flow and critical effluent flow	= ???????
Cs	=	Critical upstream pollutant concentration	= ???????
Cd	=	Critical effluent pollutant concentration	= ???????

$$Cr = \frac{QsCs + QdCd}{Qr}$$

WQBELs Part III-20

Steady-State Complete Mix Assessment
QsCs + QdCd = QrCr

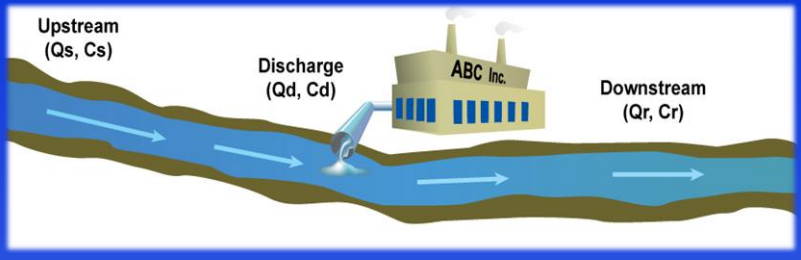


$$Cr = \frac{QsCs + QdCd}{Qr}$$

Qd = Critical *effluent flow* from discharge flow data

WQBELs Part III-21

Calculating Receiving Water Concentration Under Critical Conditions



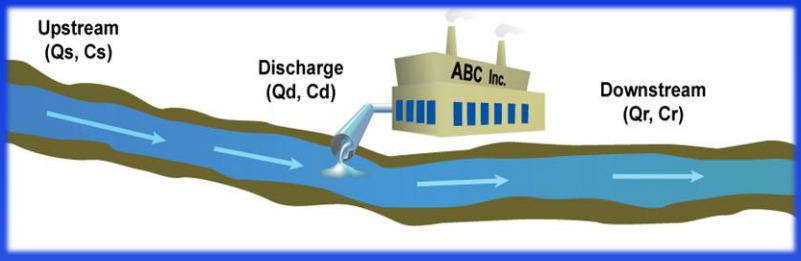
Criterion for protection of aquatic life from acute effects from Pollutant X: = 1.0 mg/L

Qs	=	Critical stream flow (1Q10) for acute criterion	= 1.2 cfs
Qd	=	Critical effluent flow from discharge flow data	= 0.31 cfs
Qr	=	Sum of critical stream flow and critical effluent flow	= ???????
Cs	=	Critical upstream pollutant concentration	= ???????
Cd	=	Critical effluent pollutant concentration	= ???????

$$Cr = \frac{QsCs + QdCd}{Qr}$$

WQBELs Part III-22

Steady-State Complete Mix Assessment
QsCs + QdCd = QrCr

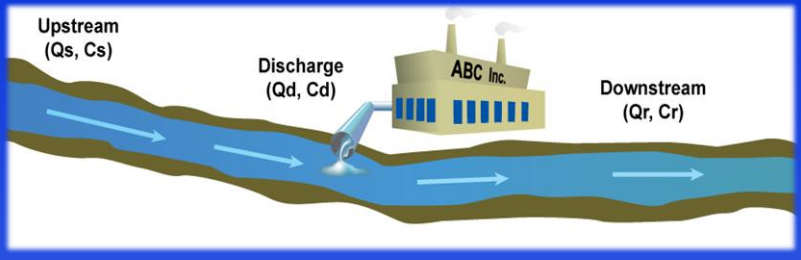


$$Cr = \frac{QsCs + QdCd}{Qr}$$

Qr = ***Sum*** of upstream flow (Qs) and discharge flow (Qd)

WQBELs Part III-23

Calculating Receiving Water Concentration Under Critical Conditions



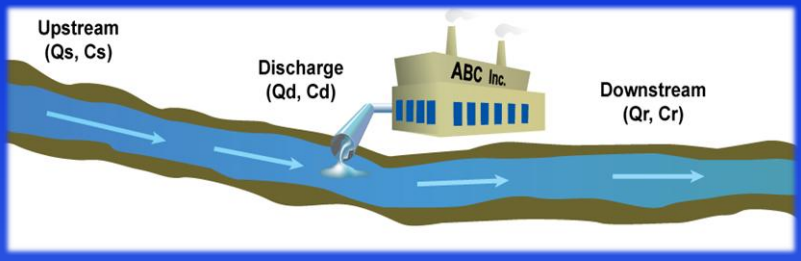
Criterion for protection of aquatic life from acute effects from Pollutant X: = 1.0 mg/L

Qs	=	Critical stream flow (1Q10) for acute criterion	= 1.2 cfs
Qd	=	Critical effluent flow from discharge flow data	= 0.31 cfs
Qr	=	Sum of critical stream flow and critical effluent flow	= 1.51 cfs
Cs	=	Critical upstream pollutant concentration	= ???????
Cd	=	Critical effluent pollutant concentration	= ???????

$$Cr = \frac{QsCs + QdCd}{Qr}$$

WQBELs Part III-24

Steady-State Complete Mix Assessment
QsCs + QdCd = QrCr

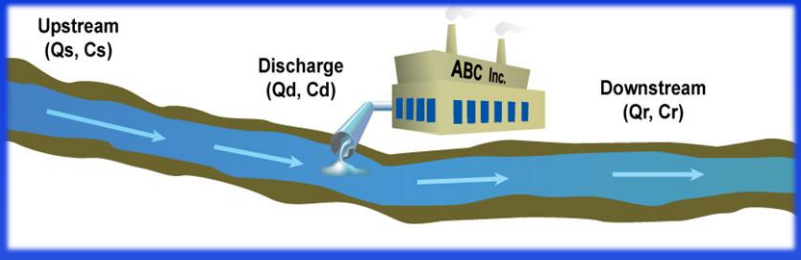


$$Cr = \frac{QsCs + QdCd}{Qr}$$

Cs = Critical ***background*** (upstream) pollutant ***concentration*** from ambient monitoring data

WQBELs Part III-25

Calculating Receiving Water Concentration Under Critical Conditions



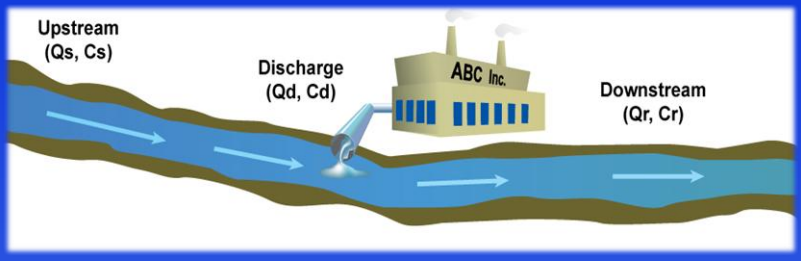
Criterion for protection of aquatic life from acute effects from Pollutant X: = 1.0 mg/L

Qs	=	Critical stream flow (1Q10) for acute criterion	= 1.2 cfs
Qd	=	Critical effluent flow from discharge flow data	= 0.31 cfs
Qr	=	Sum of critical stream flow and critical effluent flow	= 1.51 cfs
Cs	=	Critical upstream pollutant concentration	= 0.80 mg/L
Cd	=	Critical effluent pollutant concentration	= ???????

$$Cr = \frac{QsCs + QdCd}{Qr}$$

WQBELs Part III-26

Steady-State Complete Mix Assessment
QsCs + QdCd = QrCr



$$Cr = \frac{QsCs + QdCd}{Qr}$$

Cd = Critical *effluent* pollutant *concentration*

WQBELs Part III-27

Determining a Maximum (Critical) Value for Cd

Examine data for ABC, Incorporated

- Number of samples (N) = 6
- Concentrations of Pollutant X:
  - Cd(1) = 1.2 mg/L
  - Cd(2) = 0.82 mg/L
  - Cd(3) = 0.87 mg/L
  - Cd(4) = 1.3 mg/L
  - Cd(5) = 0.74 mg/L
  - Cd(6) = 1.0 mg/L
- Maximum Observed Value of Effluent Concentration = 1.3 mg/L
- ***Would this Cd represent the "critical" condition?***

WQBELs Part III-28

Determining a Maximum (Critical) Value for Cd

- **Answer: Not likely**
  - **Our limited data set does not account for day-to-day *variability* in effluent quality (i.e., the facility probably did not self-monitor on its worst possible day).**
  - **When determining reasonable potential, "…..the permitting authority shall use procedures which account for…..the *variability* of the pollutant or pollutant parameter in the effluent…" *[40 CFR 122.44(d)(1)(ii)].***

WQBELs Part III-29

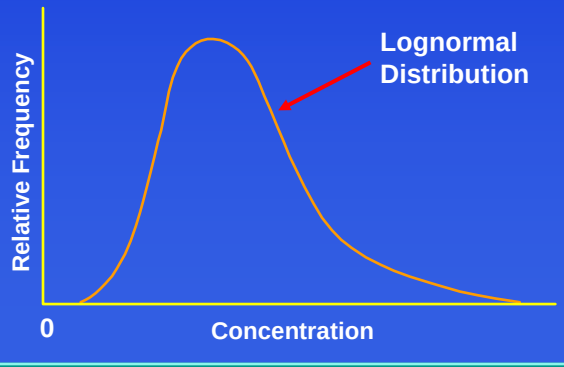
Determining a Maximum (Critical) Value for Cd

- **Follow permitting authority procedures to determine the critical value for Cd**
  - **Permitting authority regulation, policy, or guidance**
  - **EPA's *Technical Support Document for Water Quality-based Toxics Control* (TSD)**
    - **Uses a statistical analysis that assumes effluent data follow a *lognormal distribution***

WQBELs Part III-30

Some Key Terms

- ***Lognormal Distribution:*** **the probability distribution of any random variable whose logarithm is normally distributed**
  - ***Relative Frequency:*** **the fraction or ratio of the number of observations in a category or class to the total number of observations**



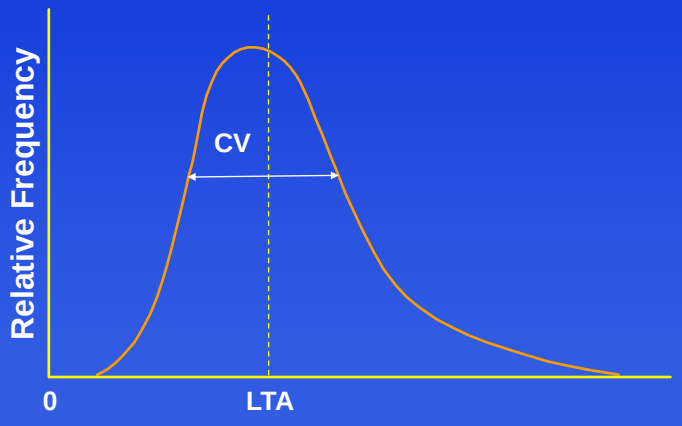
WQBELs Part III-31

Some Key Terms

- ***Long-term Average (LTA):*** **for a continuous random variable (in our case, pollutant concentration), the value at which the area under the distribution curve to the left of the value equals the area under the distribution curve to the right of the value**
- ***Coefficient of Variation (CV):*** **a statistical measure of the relative variation of a distribution or set of data (in our case, pollutant concentrations) calculated as the standard deviation divided by the mean**

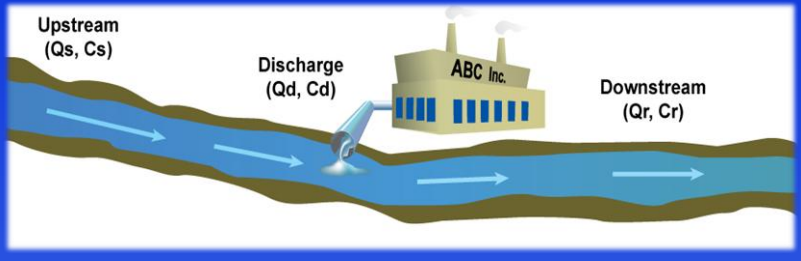
WQBELs Part III-32

Defining a Lognormal Distribution Using LTA and CV



WQBELs Part III-33

Steady-State Complete Mix Assessment QsCs + QdCd = QrCr

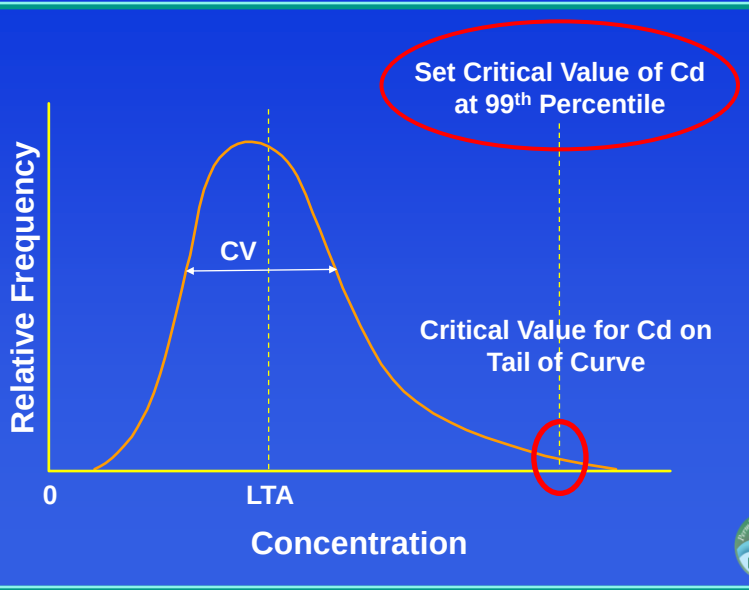


$$Cr = \frac{QsCs + QdCd}{Qr}$$

Recall….we want to determine the critical *effluent* pollutant *concentration (Cd)*

WQBELs Part III-34

Determining a Critical Value for Cd



WQBELs Part III-35

Determining a Critical Value for Cd

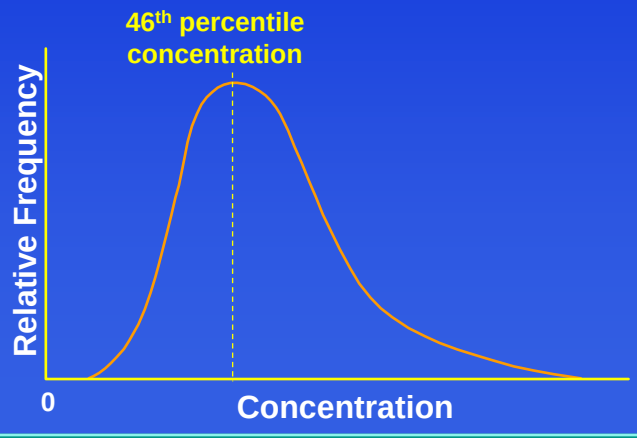
Examine data for ABC, Incorporated using the TSD statistical approach

- Number of samples (N) = 6
- Concentrations of Pollutant X:
  - Cd(1) = 1.2 mg/L
  - Cd(2) = 0.92 mg/L
  - Cd(3) = 0.87 mg/L
  - Cd(4) = 1.3 mg/L
  - Cd(5) = 0.74 mg/L
  - Cd(6) = 1.0 mg/L
- CV = 0.6 (EPA recommends a default CV value of 0.6 if there are < 10 data points available)
- Maximum Observed Value of Effluent Concentration = 1.3 mg/L

WQBELs Part III-36

Determining a Critical Value for Cd

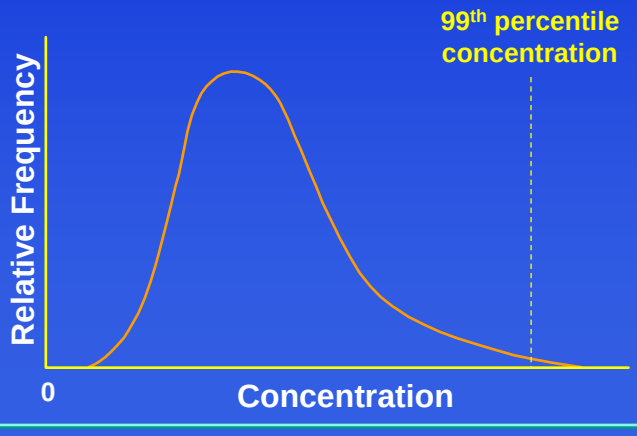
Statistics tell us that we can be 99% sure that the largest value of our 6 measurements of the concentration of Pollutant X will be at or greater than the ***46th percentile*** of the lognormal distribution of all effluent pollutant concentrations for ABC, Inc.



WQBELs Part III-37

Determining a Critical Value for Cd

To be 99 percent sure that we have captured the ***99th percentile*** concentration of Pollutant X (which we will call the ***critical or upper-bound*** concentration), we need the highest concentration measured from 330 samples of ABC Inc.'s effluent



WQBELs Part III-38

Determining a Critical Value for Cd

Our options:

1. Measure the concentration of Pollutant X in *330 separate samples* of ABC, Inc.'s effluent
2. Use statistics for the lognormal distribution to find a *multiplier* that lets us *estimate* the 99th percentile (which is what we want to find) from the 46th percentile (which is represented by the highest of our 6 measured concentrations)

- For any data set, to estimate the upper bound value, we need to know:
  - Number of samples collected (N)
  - Coefficient of variation (CV)
    - Use a default of 0.6 if N < 10

WQBELs Part III-39

Reasonable Potential Multiplying Factors

(99% Confidence Level and 99% Probability Basis

Sample Number

Coefficient of Variation

N	0.2	0.4	0.6	0.8	1.0	1.2	1.4	1.6	1.8	2.0
1	2.5	6.0	13.2	26.5	48.3	81.4	128.0	190.3	269.9	368.3
2	2.0	4.0	7.4	12.7	20.2	30.3	43.0	58.4	76.6	97.5
3	1.9	3.3	5.6	8.9	13.4	19.0	25.7	33.5	42.3	52.0
4	1.7	2.9	4.7	7.2	10.3	14.2	18.6	23.6	29.1	35.1
5	1.7	2.7	4.2	6.2	8.6	11.5	14.8	18.4	22.4	26.5
6	1.6	2.5	3.8	5.5	7.5	9.8	12.4	15.3	18.3	21.5
7	1.6	2.4	3.6	5.0	6.7	8.7	10.8	13.1	15.6	18.2
8	1.5	2.3	3.3	4.6	6.1	7.8	9.6	11.6	13.6	15.8
9	1.5	2.2	3.2	4.3	5.7	7.1	8.7	10.4	12.2	14.0
10	1.5	2.2	3.0	4.1	5.3	6.6	8.0	9.5	11.0	12.6
11	1.4	2.1	2.9	3.9	5.0	6.2	7.4	8.8	10.1	11.5
12	1.4	2.0	2.8	3.7	4.7	5.8	7.0	8.1	9.4	10.6
13	1.4	2.0	2.7	3.6	4.5	5.5	6.5	7.6	8.7	9.9
14	1.4	2.0	2.6	3.4	4.3	5.2	6.2	7.2	8.2	9.2
15	1.4	1.9	2.6	3.3	4.1	5.0	5.9	6.8	7.7	8.7
16	1.4	1.9	2.5	3.2	4.0	4.8	5.6	6.5	7.3	8.2
17	1.4	1.9	2.5	3.1	3.8	4.6	5.4	6.2	7.0	7.8
18	1.4	1.9	2.4	3.0	3.7	4.4	5.2	5.9	6.7	7.4
19	1.4	1.8	2.4	3.0	3.6	4.3	5.0	5.7	6.4	7.1
20	1.3	1.8	2.3	2.9	3.5	4.2	4.8	5.5	6.1	6.8

3.8

WQBELs Part III-40

Determining a Critical Value for Cd

Examine data for ABC, Incorporated using the TSD statistical approach

- Number of samples (N) = 6
- Concentrations of Pollutant X:

Cd(1) = 1.2 mg/L	Cd(2) = 0.92 mg/L
Cd(3) = 0.87 mg/L	Cd(4) = 1.3 mg/L
Cd(5) = 0.74 mg/L	Cd(6) = 1.0 mg/L

- CV = 0.6 (default value if N < 10)
- Maximum Observed Value of Effluent Concentration = 1.3 mg/L

WQBELs Part III-41

Determining a Critical Value for Cd

Projected Critical (99th percentile) Value of Cd =

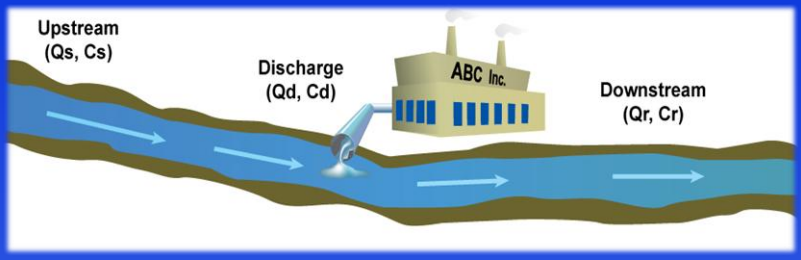
1.3 mg/L x multiplier =

1.3 mg/L x 3.8 = 5.0 mg/L

Cd = 5.0 mg/L

WQBELs Part III-42

Calculating Receiving Water Concentration Under Critical Conditions



Criterion for protection of aquatic life from acute effects from Pollutant X: = 1.0 mg/L

Qs	=	Critical stream flow (1Q10) for acute criterion	= 1.2 cfs
Qd	=	Critical effluent flow from discharge flow data	= 0.31 cfs
Qr	=	Sum of critical stream flow and critical effluent flow	= 1.51 cfs
Cs	=	Critical upstream pollutant concentration	= 0.80 mg/L
Cd	=	Critical effluent pollutant concentration (*projected*)	= 5.0 mg/L

$$Cr = \frac{QsCs + QdCd}{Qr}$$

WQBELs Part III-43

Expected Receiving Water Concentration
(Steady-State, Rapid and Complete Mix Under Critical Conditions)

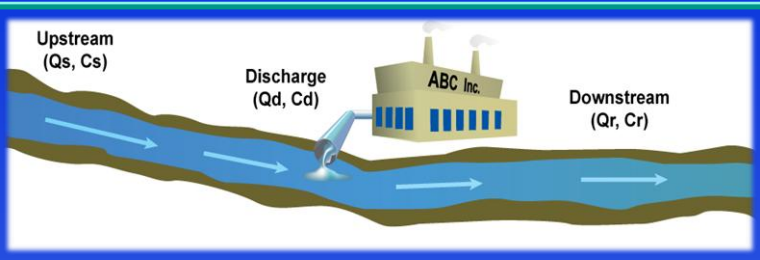
$$Cr = \frac{QsCs + QdCd}{Qr}$$

$$Cr = \frac{(1.2\ cfs)(0.80\ mg/L) + (0.31\ cfs)(5.0\ mg/L)}{(1.2\ cfs) + (0.31\ cfs)}$$

$$Cr = 1.7\ mg/L$$

WQBELs Part III-44

Is There Reasonable Potential?
(Steady-State, Rapid and Complete Mix Under Critical Conditions)

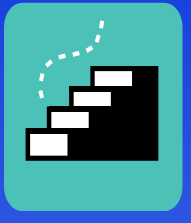


- **For ABC, Incorporated:**
  - **Projected Cr = 1.7 mg/L > 1.0 mg/L (acute criterion)**
  - **The discharge of Pollutant X from ABC, Incorporated would cause, have the reasonable potential to cause, or contribute to an excursion of the acute aquatic life criterion.**
  - ***The permit writer must calculate WQBELs for Pollutant X.***

WQBELs Part III-45

What Next?

- **In our example, where we considered only the acute aquatic life criterion, we still would need to consider, if available:**
  - **chronic aquatic life criterion**
  - **human health criteria**
  - **wildlife criteria**
  - **etc.**



WQBELs Part III-46

What Next? (continued)

- Repeat the entire analysis for additional pollutants of concern and additional outfalls
- For each pollutant for which we determine there is reasonable potential to exceed ***any*** of the criteria for that pollutant, ***calculate chemical-specific WQBELs (Part IV)***
- When there is no reasonable potential
  - determine whether any existing limitations should be retained
  - consider appropriate monitoring requirements

WQBELs Part III-47

Feedback and Other Presentations

Questions or comments?

npdeswebtraining@tetratech.com

Join us for other online presentations on NPDES Permitting

www.epa.gov/npdes/training

WQBELs Part III-48